Double-antenna and radio apparatus

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The invention relates to an arrangement for enhancing electrical isolation between antennas in antenna structures comprising at least two antennas, and a radio device applying the arrangement. To enhance antenna isolation, the interfering antenna includes components causing substantial degradation in the radiation characteristics in the operating band of another antenna. For example, a PIFA (310) may include, instead of a short-circuit conductor, a conductive structure (312, 313, 314) having a parallel resonance in the operating band of another antenna (320). Mutual interference of radio parts using separate antennas can be made relatively small without electrical isolation arrangements between antenna elements. Moreover, the invention makes antenna filter design easier and reduces disadvantages caused by antenna filters.

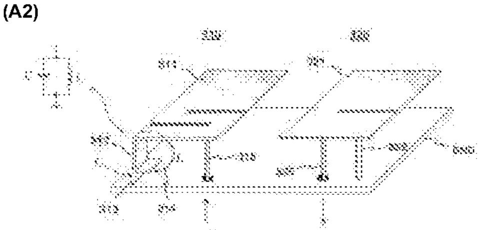

Fig. 3

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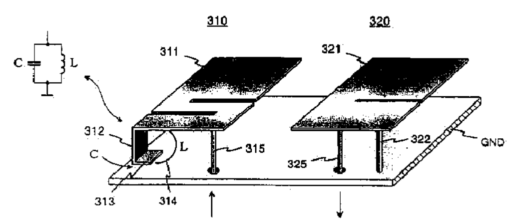
权利要求书 2 页 说明书 7 页 附图 5 页

[54] 发明名称 双天线和无线电设备

[57] 摘要

本发明涉及用于在至少包括两根天线的天线结构中增强天线之间电绝缘的装置以及应用该装置的无线电设备。为增强天线绝缘，干扰天线包括在另一天线的操作频带中造成辐射特性大大降低的部件。例如，PIFA(310)可包括在另一天线(320)的操作频带中具有并联谐振的导电结构(312、313、314)而不是短路导体。使用独立天线的无线电部件的相互干扰可以变得相对较小并无需在天线单元之间的电绝缘装置。此外，本发明使天线滤波器设计更容易且减少了天线滤波器引起的缺陷。



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1. 一种用于增强天线之间电绝缘的装置，所述天线包括属于同一个无线电设备的第一天线和第二天线，其特征在于至少所述第一天线（310；410；610；710；810）包括降低其在所述第二天线（320；420）的操作频带上的匹配的结构部件。

2. 如权利要求 1 所述的装置，其中所述第一天线是 PIFA，其特征在于所述降低所述第一天线（310；410；810）的所述匹配的结构部件构成并联谐振电路，所述并联谐振电路代替所述 PIFA 中的短路导体，并且所述并联谐振电路的谐振频率基本上与所述第二天线（320；420）的谐振频率相同。

3. 如权利要求 2 所述的装置，其特征在于所述并联谐振电路包括在所述辐射平面和地平面之间在某个对应于所述第一天线的短路点的点上基本为电感性的电路元件（314；414；812a；812b），以及在对应于所述短路点的某个区域中大大增强电容值的电容性电路元件（312；313；412；413；813）。

4. 如权利要求 1 所述的装置，其中所述第一天线是 PIFA，其特征在于所述降低所述第一天线的所述匹配的结构部件构成串联谐振电路，所述串联谐振电路代替所述 PIFA 中的馈电导体，并且所述串联谐振电路的所述谐振频率基本上与所述第一天线的所述谐振频率相同。

5. 如权利要求 4 所述的装置，其特征在于所述串联谐振电路包括基本上为电感性的电路元件（515）和形成串联电容值的电容性电路元件（516）。

6. 如权利要求 1 所述的装置，其中所述第一天线是 PIFA，其特征在于所述降低所述第一天线的所述匹配的所述结构部件构成代替所述 PIFA 中的短路导体的电感性电路元件（612）和代替所述 PIFA 中的馈电导体的电容性电路元件（615；617；602）。

7. 如权利要求 1 所述的装置，其中所述第一天线是 PIFA，其特征在于所述装置包括在所述第一天线（710；810）的所述辐射平面与地平面之间的电路板（707；807），并且所述降低所述第一天线的所述匹配的所述结构部件位于所述电路板上。

8. 如以上任一权利要求所述的装置，其特征在于所述电容性电路元件由与所述第一天线中所述辐射平面和/或地平面连接的导电材料（312；412；413；615；617）构成。

9. 如权利要求 1-7 中任何一项所述的装置，其特征在于所述电容性电路元件包括分立电容（516；716；813）。

10. 如以上任一权利要求所述的装置，其特征在于所述电感性电路元件由与所述第一天线中的所述辐射平面和/或地平面连接的导电材料（314；414；515；612；715；812a；812b）构成。

11. 如以上任一权利要求所述的装置，其特征在于所述电感性电路元件包括线圈。

12. 如权利要求 11 所述的装置，其特征在于所述线圈是电路板（807）的表面上螺旋状的微型条（812a）。

13. 一种具有第一天线和第二天线的无线电设备（MS），其特征在于至少所述第一天线（010）包括降低其在所述第二天线（020）的操作频带上的匹配进而增强所述天线之间的所述电绝缘的结构部件（012）。

双天线和无线电设备

技术领域

本发明涉及一种用于在至少包括两根天线的天线结构中增强天线之间电绝缘的装置。本发明还涉及采用根据本发明的双天线的无线电设备。

背景技术

近年来，常见到在两个或更多无线电系统中操作的便携式通信设备。如果在某个时间这样一种通信设备仅在一个系统中工作，则它通常配备一根天线，该天线具有两个操作频带或一个频带，但这一个频带的频宽足以覆盖例如两个系统使用的两个频带。如果通信设备可以同时在两个系统中工作，特别是如果系统的频带彼此相当接近，则可使用两根独立天线。使用独立天线时，系统的相互干扰可以做得小于一根公共天线的情况。然而，由于在天线之间存在一定的电磁耦合，因此相互干扰并没有完全去除。原则上，此问题可以通过增加天线之间的距离而得到缓和，但这实际上会使结构太大。干扰发射机也可以配备天线滤波器，其衰减在被影响接收机的操作频带所处的通带侧大大增加。这样一种滤波器等级很高，从而产生更高的生产成本和与滤波器通带衰减相关的问题。功率放大器与天线之间所有增加的损耗将导致功率放大器中电流消耗上升和潜在的设备发热问题。

也可以通过在天线之间配置电绝缘来降低它们之间的电磁耦合。图 1 说明了这样一种已知方案。图 1 显示根据第一系统操作的发射机天线端和根据第二系统操作的接收机天线端。发射机包括串联的 RF 功率放大器 PA、发射端天线滤波器 SFI 和发射天线 110。滤

波器 SFI 相对简单，其通带衰减不高，不会造成有害影响。接收机包括连接到接收端天线滤波器 RFI 的接收天线 120，而接收端天线滤波器 RFI 又连接到低噪声放大器 LNA。第一系统例如是 GSM1800（全球移动通信系统），而第二系统是例如其中接收频率为 1574.42 MHz 的 GPS（全球定位系统）。这种情况下，由于 GPS 接收频率与 GSM 发射频带之间的间隔只是 135 MHz，因此 GPS 接收将易受到 GSM 发射的影响。在图 1 中，天线标号之间有一条线 105，它指的是一种电磁绝缘发射和接收天线的装置。这样一种装置可以是例如放在天线部件之间的接地金属条。这种方案的缺点是它增加了硬件数量和生产成本。此外，天线的定向特性也受到损害。

发明内容

本发明的一个目的是减少与现有技术相关的所述缺点。根据本发明的天线结构的特征在于独立权利要求 1 中指定的特征。根据本发明的无线电设备的特征在于独立权利要求 13 中指定的特征。本发明的一些有利实施例在其它权利要求中指定。

本发明的基本思想如下：天线结构包括至少两根相邻但具有不同操作频带的独立天线。干扰天线包括可在另一天线操作频带上大大降低辐射特性的结构部件。这减少了另一天线连接的接收机中的干扰电平。为实现本发明，PIFA（平面倒 F 型天线）例如可具有在另一天线操作频率中具有并联谐振的导体结构，而不是短路导体。

本发明的一个优点是使用独立天线的无线电部件的相互干扰可变得相对很小，但无需在天线单元之间使用电绝缘装置。这是基于以下事实：干扰天线的发射功率在另一天线的操作频带中下降。本发明的另一优点是它使天线滤波器设计更容易并减少了天线滤波器引起的缺陷。本发明的再一个优点是根据本发明的装置将不会影响天线的定向特性。本发明的又一个优点是必需的结构部件可部分地连同天线单元生产一起实现，而无需额外的生产阶段。

附图说明

下面将详细描述本发明。描述参照附图，其中：

图 1 显示根据现有技术的天线绝缘方案；

图 2 示意性地显示根据本发明的天线绝缘方案；

图 3 显示根据本发明的天线结构的一个示例；

图 4 显示根据本发明的天线结构的第二示例；

图 5 显示根据本发明的天线结构的第三示例；

图 6 显示根据本发明的天线结构的第四示例；

图 7a、b 显示根据本发明的天线结构的第五示例；

图 8a、b 显示根据本发明的天线结构的第六示例；

图 9 显示根据本发明的装置的天线绝缘效果示例；

图 10 显示配有根据本发明的天线的无线电设备的示例。

具体实施方式

图 1 已结合现有技术描述进行了讨论。

图 2 示意性地显示了根据本发明的天线绝缘方案。与图 1 相同，图 2 也显示了根据第一系统操作的发射机天线端和根据第二系统操作的接收机天线端。与图 1 的不同之处在于发射天线 210 与接收天线 220 之间现在没有电磁绝缘装置。相反，图 2 显示了标号 215，它指的是发射天线结构中包括的用于提供天线电磁绝缘的装置。实现绝缘后，装置 215 使发射天线 210 的辐射特性在接收天线 220 的操作频带中产生实质性下降。

图 3 显示根据本发明的天线结构示例。它包括两个 PIFA 类型的天线，其中将整体的相当大的地平面 GND 用作接地电极。第一天线 310 包括辐射平面 311，虽然它也可以作为双向系统的接收天线，但让我们称其为发射天线。第二天线 320 包括辐射平面 321，虽然它也可以作为双向系统的发射天线，但让我们称其为接收天线。接收天线 320 还包括常规短路导体 322 和馈电导体 325。

发射天线 310 的馈电导体 315 也是常规的。但是，短路导体是根据本发明的。在此示例中，短路导体，或实际上的短路装置包括导线 314 和辐射平面 311 的延伸 312，一直到地平面，该延伸具有与地平面 GND 平行的导电板 313。导电板 313 与地平面彼此很近，从而在它们之间存在有效电容 C。导线 314 的形状在此示例中是弓形的。它的一端连接到地平面而另一端连接到辐射平面靠近其延伸 312 的开始处。导线很细，因而除电容 C 外，它还产生了有效电感 L。得到的并联谐振电路的大小应使得其谐振频率等于接收天线 320 接收频带的中心频率。所述谐振电路的阻抗在发射天线 310 的操作频带中很小，因此，天线辐射和接收良好。在接收天线的操作频带中，所述谐振电路的阻抗很高，而发射天线的匹配很差，因此其辐射很弱。由于操作现在不在发射天线合适的操作频带进行，这时的匹配当然会降低。然而，如果天线频带彼此相当靠近，则这不会在它们之间产生足够的绝缘。根据本发明的装置明显增强了绝缘。

图 3 未显示辐射平面的任何支撑结构。这样一种结构可包括例如沿平面边缘的电介质框。

图 4 显示了根据本发明的天线结构的第二示例。与图 3 一样，具有两根彼此非常靠近的平行天线。各天线的辐射元件在这种情况下是印刷电路板 401 表面上的导电图。接收天线 420 的辐射/接收元件是弯曲的图案。发射天线 410 是 PIFA。在此示例中该天线具有两个频带，这是由于辐射平面 411 被绝缘槽 419 分成两个不同长度的分支。发射天线与图 3 所示结构相同，它包括作为并联谐振电路的短路装置。这种情况下，短路装置包括连接到辐射平面 411 的第一导电块 412、连接到地平面 GND 的第二导电块 413 以及导线 414。第一和第二导电块彼此面对。它们相对的表面是平的且彼此很近，因此在第一导电块和第二导电块之间存在有效电容 C。第一导电块可以和辐射平面 411 形成单个实体，而第二传导块可以和接地平面形成单一实体。导线 414 从地平面开始，形成单个环形，经过电路板

中的通孔，并在辐射平面的第一导电块连接点附近终止。导线 414 具有某个电感值 L。

图 5 显示根据本发明的天线结构的第三示例。在此示例中，第一天线，即发射天线是 PIFA，而第二天线，或接收天线是单极天线，其鞭状元件 521 可以被推入无线电设备中。两根天线共享的地平面 GND 此处是无线电设备中印刷电路板 505 表面上的导电平面。在此示例中，发射天线的短路导体 512 是常规装置，但天线馈电装置是根据本发明的装置。常规馈电导体被替换为串联的分立电容 516 和导体 515。从发射天线的辐射平面 511 的方向看，电容位于印刷电路板 505 的另一侧。电容的一个电极连接到馈电天线端口 AP，并且导体 515 的一端连接到辐射平面 511 的馈电点 F。所选导体 515 的厚度以使其电感值 L 适合为准。串联谐振电路被设计为使其谐振频率等于发射天线操作频带的中心频率。串联谐振电路的阻抗在发射天线的操作频带中很小，因此天线的辐射和接收良好。在接收天线的操作频带中，串联谐振电路的阻抗很高，而发射天线的匹配很差，因此其发射很弱。

图 5 显示了支撑辐射平面 511 的框架 508 的小部分。除延伸的鞭状元件下端旁印刷电路板 505 上的绝缘块 529，未显示鞭状元件 521 的支撑结构。鞭状天线的馈电导体 525 通过所述块进入所述块 529 上的接触面。

图 6 显示了根据本发明的天线结构的第四示例。在两根天线中，仅显示了发射天线，其发射倾向于干扰另一天线的接收。在此示例中，发射天线 610 也是 PIFA；它在辐射面的 F 点馈电，并具有短路导体 612。无线电设备中电路板 605 的上表面，或者说离辐射平面最近的表面上的导电层用作地平面 GND。馈电是电容性的。发射天线的天线端口 AP 的“热”电极电连接到电路板 605 的上表面上的导电区 602，该区域与接地平面隔离。在此导电区之上，有一块平行导电板 617，它通过导体 615 电连接到辐射平面上它的馈电点 F。在导电

区 602 与导电板 617 之间，存在一定的电容值 C。所述导体之间的间隔可包括空气或某种电介质材料，以增加电容值并稳定结构。短路导体 612 很薄，因而其电感值 L 对天线的操作是重要的。除了此处显示的直导体，它自然可以是绕成线圈的导体。

图 6 还显示了天线 610 的简化等效电路。从天线端口 AP 开始并沿着馈电导体，首先是电容值 C 和馈电点 F。在后者与信号接地之间有天线辐射电阻值 R_r。从馈电点开始到辐射平面的短路点 S，存在某种主要为电抗性的阻抗 Z。在短路点与信号地之间存在电感值 L。天线端口的另一电极连接到信号地。所选电容 C 和电感 L 的值应使得发射天线在其自己的操作频带中匹配，即可从天线端口中“看到”的阻抗几乎是电阻性的并且相当接近于馈电源的内部阻抗。当移入另一天线的操作频带时，由于辐射电阻值变为电抗性的，并且根据本发明，由于电感值 L 和电容值 C 的原因，发射天线的匹配会下降。

图 7a 和 b 显示根据本发明的天线结构的第五示例。两根天线中，仅显示了发射天线，其发射倾向于干扰另一天线的接收。图 7a 中从馈电和短路导体侧显示了发射 PIFA 710，而在图 7b 中还横向但从图 7a 所示位置水平旋转 90 度显示了发射 PIFA 710。在此示例中，辐射平面 711 与地平面 GND 之间有一个小电路板 707 延伸在其间。电路板 707 包括直微型条 712 和微型条 715，直微型条 712 用作短路导体，而微型条 715 用作馈电导体。后者很薄，因而具有有效电感。在这里，馈电条 715 的下端连接到天线 710 的天线端口 AP。馈电条的中间点电容性地通过电路板 707 上的片状电容 716 连接到地。这种馈电配置的设计使得发射天线在其操作频带中匹配良好，但在接收天线的操作频带中相对较差。

图 8a 和 b 显示了根据本发明的天线结构的第六示例。这种情况下，也未显示要屏蔽的接收天线。图 8a 中从馈电和短路导体侧显示了发射 PIFA 810。在辐射平面 811 与地平面 GND 之间有一个小印刷电路板 807 延伸在其间。图 8b 中从后面对其进行了图示，即从天线

810 内所显示的。印刷电路板 807 包括直馈电微型条 815 和短路条 812a 与 812b。印刷电路板正面上第一短路条 812a 从辐射平面 811 开始，并形成长方形的“螺旋”以增加电感值。在经过通孔后，它在印刷电路板后侧的另一短路条 812b 的继续。后者通过其下端连接到地平面。在印刷电路板后侧，也有与短路条 812a、b 所形成的线圈并联的片状电容 813。所得到的谐振电路在设计上与图 3 和图 4 所述的情况类似：谐振电路的阻抗在发射天线 810 的操作频带中较低，但在接收天线的操作频带中较高。

图 9 显示可以根据本发明在天线之间实现的改进电绝缘的示例。测试信号被馈入 GSM1800 系统的天线中，并且在同一无线电设备中的 GPS 接收机天线输出中进行电平测量。曲线 91 表示没有特殊 GPS 接收屏蔽时天线的绝缘衰减。绝缘衰减当然在测试信号的频率为 1575.42 MHz 或 GPS 系统中使用的频率时最小；在那时的衰减只有 3.8 dB。曲线 92 显示发射天线已根据本发明进行修改以屏蔽 GPS 接收时天线的绝缘衰减。在 GPS 频率下，发射天线中的谐振电路将绝缘衰减提高了大约 17 dB，使其达到 20.8 dB。对应于图 1 的现有技术绝缘配置实际上将产生大约 10 dB 的绝缘衰减，因此，与该装置相比，改进也相当大。

图 10 显示无线电设备 MS。它具有第一 010 和第二 020 天线。第一天线包括根据本发明的装置 012。

在上面我们论述了根据本发明的几个解决方案。本发明并不限制根据本发明的天线单元和其它部件的形状，也不限制天线的制造方法。此外，两根天线均可包括根据本发明的配置。例如，在设备包括独立的 UMTS（通用移动通信系统）和 WLAN（无线局域网）天线时，可能就是这种情况。本发明思想可在独立权利要求 1 定义的范围内以各种方式进行应用。

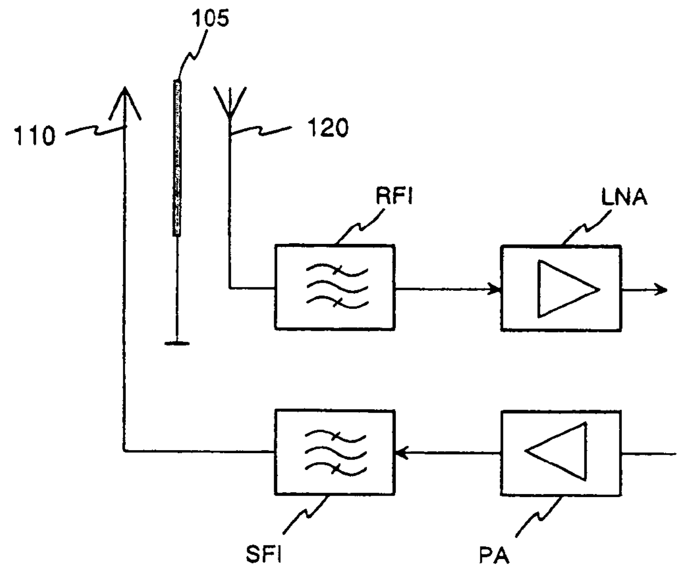


图 1

现有技术

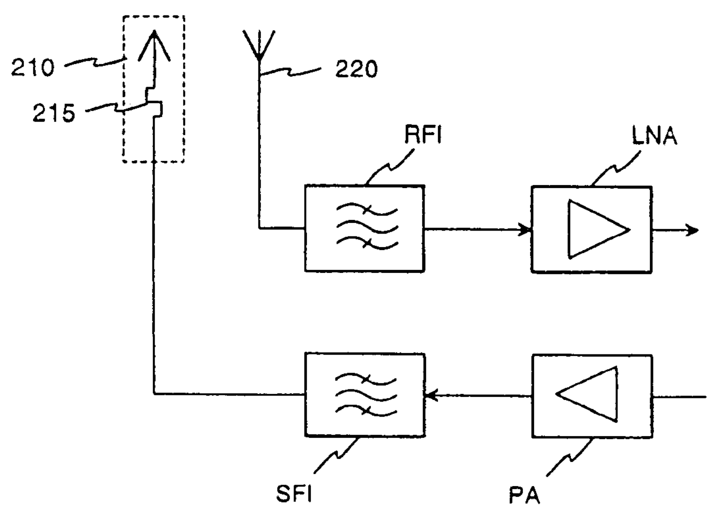
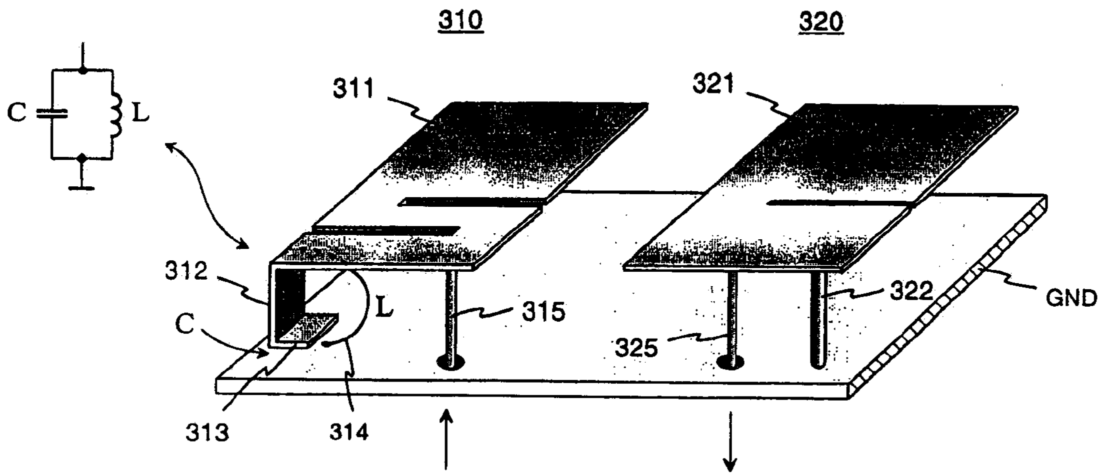


图 2

图 3


310
320
311
321
C
L
312
C
L
315
322
GND
325
313
314

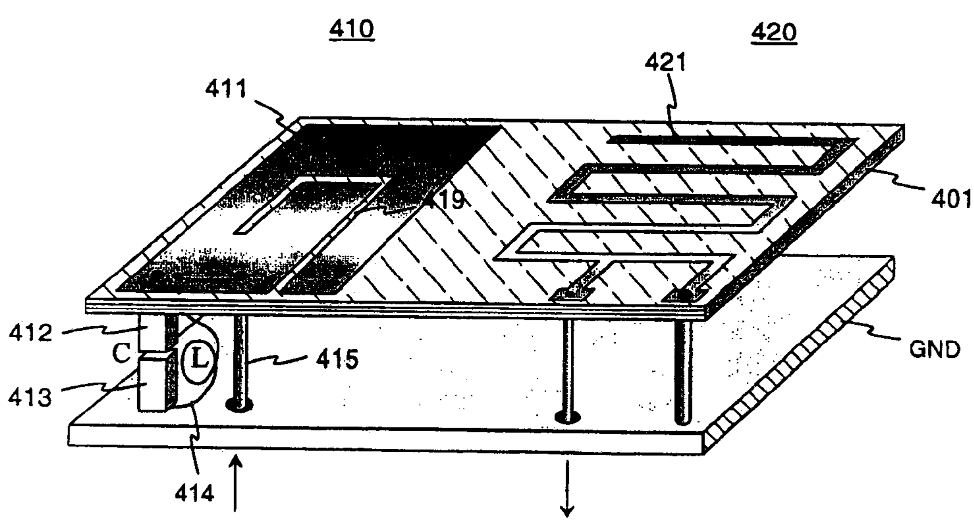

410
420
421
411
419
401
412
C
L
415
GND
413
414

图 4

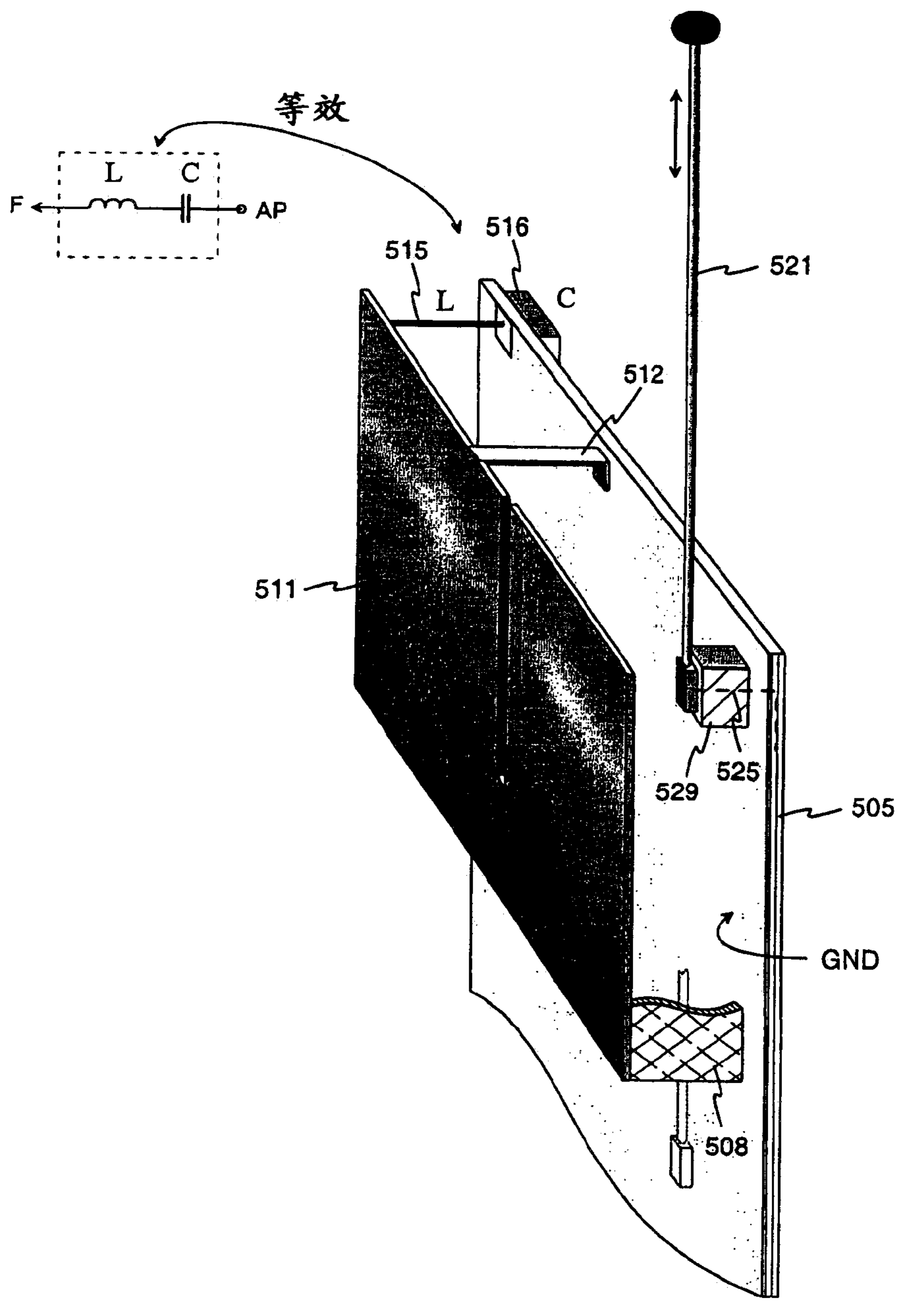


图 5

图 6

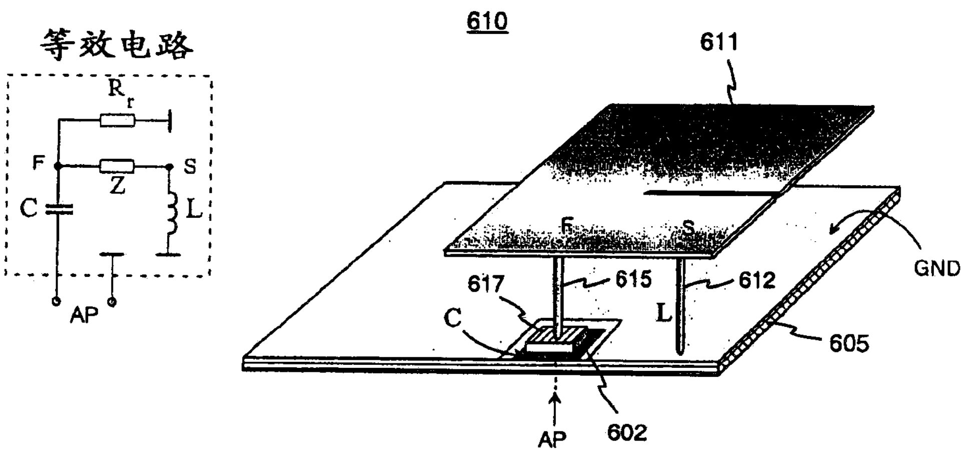


图 7a

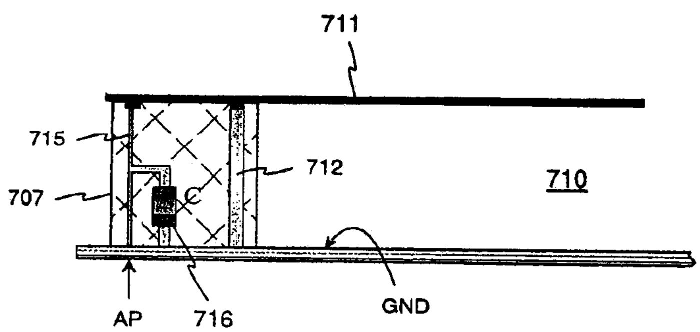
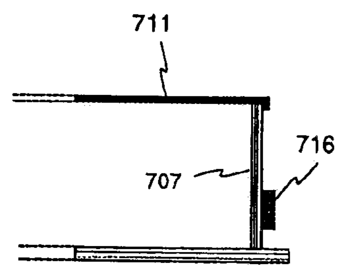


图 7b



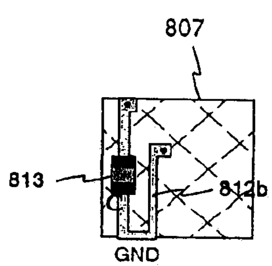


图 8b

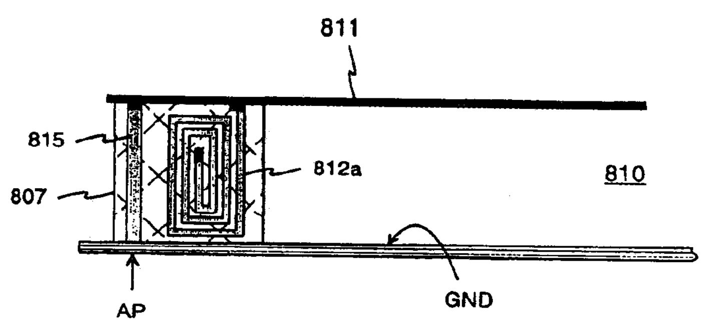
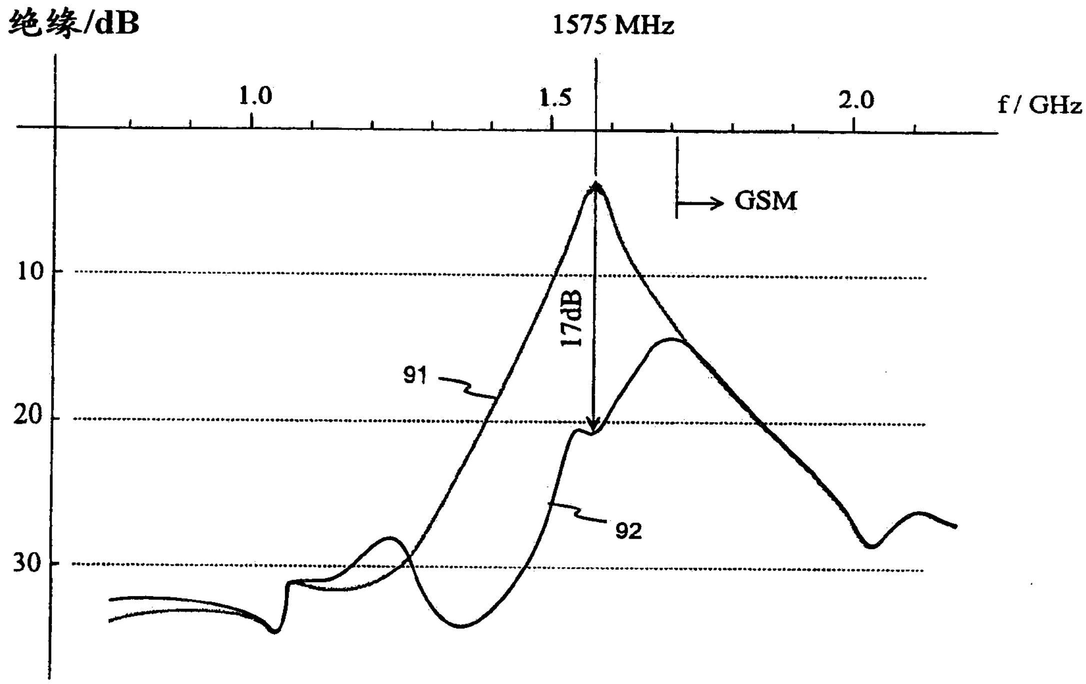


图 8a

图 9



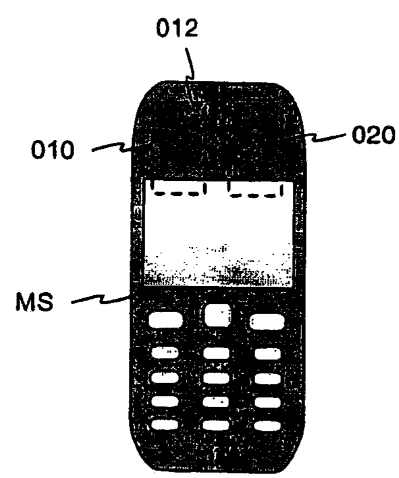


图 10

Double-antenna and radio apparatus

Description not available for **CN 1423368 (A)**
Description of corresponding document: **EP 1315238 (A2)**

[0001] The invention relates to an arrangement for enhancing electrical isolation between antennas in antenna structures comprising at least two antennas. The invention also relates to a radio device employing a dual antenna according to the invention.

[0002] Portable communications devices operating in two or more radio systems have become common in recent years. If such a communications device functions only in one system at a time, it is usually equipped with an antenna that has two operating bands or one band which is wide enough to cover both bands used by the two systems, for example. Two separate antennas may be used if the communications device can function simultaneously in two systems, especially if the frequency bands of the systems are relatively close to one another. With separate antennas, the mutual interference of the systems can be made smaller than with a common antenna. However, the mutual interference is not completely removed because there exists a certain electromagnetic coupling between the antennas. This problem can be in principle alleviated by increasing the distance between the antennas, which, however, will in practice make the structure too large. An interfering transmitter may also be equipped with an antenna filter the attenuation of which increases steeply on that side of the pass band where the operating band of the affected receiver is located. The order of such a filter is high, resulting in higher production costs and problems related to the pass-band attenuation of the filter. All increases in losses between the power amplifier and antenna will result in increased current consumption in the power amplifier and potential heating problems in the device.

[0003] Electromagnetic coupling between antennas can also be reduced by arranging electrical isolation between them. Fig. 1 illustrates such a known solution. Fig. 1 shows the antenna end of a transmitter operating according to a first system, and the antenna end of a receiver operating according to a second system. The transmitter includes a series connection of a RF power amplifier PA, transmitting end antenna filter SFI and a transmitting antenna 110. The filter SFI is relatively simple in that its pass-band attenuation is not harmfully high. The receiver includes a receiving antenna 120 which is connected to a receiving end antenna filter RFI which in turn is connected to a low-noise amplifier LNA. The first system is for example GSM1800 (Global System for Mobile Communications) and the second system e.g. GPS (Global Positioning System) in which the receiving frequency is 1575.42 MHz. In that case GPS reception will be susceptible to interference from GSM transmissions because the gap between the GPS receiving frequency and GSM transmission band is only 135 MHz. In Fig. 1 there is a line 105 between the antenna symbols, referring to an arrangement which electromagnetically isolates the transmitting and receiving antennas. Such an arrangement may be e.g. a grounded metal strip placed between the antenna elements. A disadvantage of this solution is that it increases the amount of hardware as well as production costs. Moreover, the directional characteristics of the antennas may suffer.

[0004] An object of the invention is to reduce said disadvantages associated with the prior art. An antenna structure according to the invention is characterized by that which is specified in the independent claim 1. A radio device according to the invention is characterized by that which is specified in the independent claim 13. Some advantageous embodiments of the invention are specified in the other claims.

[0005] The basic idea of the invention is as follows: An antenna structure comprises at least two adjacent but separate antennas with different operating bands. An interfering antenna comprises structural parts which cause substantial degradation of radiation characteristics at the operating band frequencies of the other antenna. This reduces interference level in the receiver to which the other antenna is connected. To realize the invention, a PIFA (planar inverted F antenna), for instance, may have, instead of a short-circuit conductor, a conductor structure which has a parallel resonance in the operating band of the other antenna.

[0006] An advantage of the invention is that mutual interference of radio parts using separate antennas can be made relatively small without using an arrangement for electrical isolation between the antenna elements. This is based on the fact that the transmission power of the interfering antenna drops in the operating band of the other antenna. Another advantage of the invention is that it makes antenna filter design easier and reduces disadvantages caused by antenna filters. A further advantage of the invention is that an arrangement according to the invention will not affect the directional characteristics of the antennas. A yet further advantage of the invention is that the necessary structural parts can be partly implemented in conjunction with antenna element manufacturing, without extra production stages.

[0007] The invention is below described in detail. The description refers to the accompanying drawings in which

Fig. 1 shows an antenna isolation solution according to the prior art,
Fig. 2 schematically shows an antenna isolation solution according to the invention,

Fig. 3 shows an example of an antenna structure according to the invention,
Fig. 4 shows a second example of an antenna structure according to the invention,
Fig. 5 shows a third example of an antenna structure according to the invention,
Fig. 6 shows a fourth example of an antenna structure according to the invention,
Figs. 7a,b show a fifth example of an antenna structure according to the invention,
Figs. 8a,b show a sixth example of an antenna structure according to the invention,
Fig. 9 shows an example of the effect of an arrangement according to the invention on antenna isolation, and
Fig. 10 shows an example of a radio device equipped with an antenna according to the invention.
Fig. 1 was already discussed in connection with the description of the prior art.

[0008] Fig. 2 schematically shows an antenna isolation solution according to the invention. Like in Fig. 1, here, too, are shown the antenna end of a transmitter operating according to a first system, and the antenna end of a receiver operating according to a second system. The difference from Fig. 1 is that the electromagnetic isolation arrangement between the transmitting antenna 210 and receiving antenna 220 is now missing. Instead, Fig. 2 shows symbol 215 referring to an arrangement included in the transmitting antenna structure to provide electromagnetic isolation of the antennas. Isolation is realized such that the arrangement 215 causes substantial deterioration in the radiation characteristics of the transmitting antenna 210 in the operating band of the receiving antenna 220.

[0009] Fig. 3 shows an example of an antenna structure according to the invention. It includes two PIFA-type antennas where a unitary, relatively massive ground plane GND serves as a ground electrode. The first antenna 310 includes a radiating plane 311. Let us call it a transmitting antenna even though it may also function as a receiving antenna of a bi-directional system. The second antenna 320 includes a radiating plane 321. Let us call it a receiving antenna even though it may also function as a transmitting antenna of a bi- directional system. The receiving antenna 320 also includes a conventional short-circuit conductor 322 and feed conductor 325.

[0010] The feed conductor 315 of the transmitting antenna 310 is conventional, too. The short-circuit conductor, instead, is in accordance with the invention. In this example, the short-circuit conductor or, actually, short-circuit arrangement comprises a conductive wire 314 and an extension 312 to the radiating plane 311, directed towards the ground plane, which extension has a conductive plate 313 parallel to the ground plane GND. The conductive plate 313 and ground plane are so close to each other that there is a significant capacitance C between them. The shape of the conductive wire 314 is in this example arcuate. It is connected by one end to the ground plane and by the other end to the radiating plane near the beginning of its extension 312. The conductive wire is so thin that it causes a significant inductance L beside the capacitance C. The resulting parallel resonance circuit is dimensioned so as to have a resonance frequency equal to the center frequency of the reception band of the receiving antenna 320. The impedance of said resonance circuit in the operating band of the transmitting antenna 310 is small, so the antenna radiates and receives well. In the operating band of the receiving antenna the impedance of said resonance circuit is high, whereby the matching of the transmitting antenna is poor and it radiates weakly. Matching is of course degraded alone by the fact that operation is now off from the operating band proper of the transmitting antenna. However, this does not produce sufficient isolation between the antennas if their bands are relatively close to one another. The arrangement according to the invention decidedly enhances the isolation.

[0011] Fig. 3 does not show any support structure for the radiating planes. Such a structure may comprise e.g. a dielectric frame along the edges of the plane.

[0012] Fig. 4 shows a second example of an antenna structure according to the invention. There are two parallel antennas in close proximity to each other, like in Fig. 3. The radiating elements of the antennas are in this case conductive patterns on the surface of a printed circuit board 401. The radiating/receiving element of the receiving antenna 420 is a meandering pattern. The transmitting antenna 410 is a PIFA. In this example is has two bands, because the radiating plane 411 is divided by a nonconductive slot 419 into two branches of different lengths. The transmitting antenna comprises a short-circuit arrangement functioning as a parallel resonance circuit, like the structure in Fig. 3. In this case the short-circuit arrangement includes a first conductive block 412 connected to the radiating plane 411, a second conductive block 413 connected to the ground plane GND, and a conductive wire 414. The first and second conductive blocks face each other. Their facing surfaces are planar and so close to each other that there exists a significant capacitance C between the first and second conductive blocks. The first conductive block may form a single entity with the radiating plane 411 and the second conductive block with the ground plane. The conductive wire 414 starts from the ground plane, makes a single loop, goes through a via in the circuit board, and ends at the radiating plane next to the connection point of the first conductive block. The conductive wire 414 has a certain inductance L.

[0013] Fig. 5 shows a third example of an antenna structure according to the invention. In this example the first, i.e. transmitting, antenna is a PIFA and the second, or receiving, antenna is a monopole the whip element 521 of which can be pushed inside the radio device. The ground plane GND shared by the both antennas is now a conductive plane on a surface of a printed circuit board 505 in the radio device. The short-circuit conductor 512 of the transmitting antenna is in this example conventional. The antenna feed arrangement, instead, is in accordance with the invention. A conventional feed conductor is replaced by a series connection of a discrete capacitor 516 and conductor 515. The capacitor is located on the opposite side of the printed circuit board 505 as seen from the radiating plane 511 of the transmitting antenna. One electrode of the capacitor is connected to the feeding antenna port AP, and one end of the conductor 515 to the feed point F of the radiating plane 511. The thickness of the conductor 515 is chosen such that its inductance L is suitable. The series resonance circuit is designed so that its resonance frequency equals the center frequency of the operating band of the transmitting antenna. The impedance of the series resonance circuit in the operating band of the transmitting antenna is small, so the antenna radiates and receives well. In the operating band of the receiving antenna the impedance of the series resonance circuit is high, whereby the matching of the transmitting antenna is poor and it radiates weakly.

[0014] Fig. 5 shows a short part of the frame 508 supporting the radiating plane 511. The support structure for the whip element 521 is not shown except for a dielectric block 529 on the printed circuit board 505 next to the lower end of the extended whip element. The feed conductor 525 of the whip antenna comes through said block into a contact surface on said block 529.

[0015] Fig. 6 shows a fourth example of an antenna structure according to the invention. Of the two antennas there is shown only the one the transmission of which tends to interfere with the reception of the other. In this example, too, the transmitting antenna 610 is a PIFA; it is fed at a point F of the radiating plane and it has a short-circuit conductor 612. A conductive layer on the upper surface, or the surface nearest to the radiating plane, of a circuit board 605 in the radio device serves as a ground plane GND. The feeding is capacitive. A "hot" pole of the antenna port AP of the transmitting antenna is galvanically connected to a conductive area 602 on the upper surface of the circuit board 605, which area is insulated from the ground plane. Above this conductive area there is a parallel conductive plate 617, galvanically coupled through conductor 615 to the radiating plane at its feed point F. Between the conductive area 602 and conductive plate 617 there is a certain capacitance C. The gap between the conductors in question may contain air or some dielectric material to increase the capacitance and stabilize the structure. The short-circuit conductor 612 is so thin that its inductance L is significant to the operation of the antenna. Instead of the straight conductor shown here it may naturally be a conductor wound in a coil.

[0016] Fig. 6 further shows a simplified equivalent circuit of the antenna 610. Starting from the antenna port AP and following the feed conductor, there is first a capacitance C and feed point F. Between the latter and signal ground there is antenna radiation resistance Rr. From the feed point there is a certain, mainly reactive, impedance Z to the short-circuit point S of the radiating plane. Between the short-circuit point and signal ground there is an inductance L. The other pole of the antenna port is connected to the signal ground. The values of the capacitance C and inductance L are chosen such that the transmitting antenna is matched in its own operating band, i.e. the impedance that cab be "seen" in the antenna port is nearly resistive and relatively near the internal impedance of the feeding source. When shifting into the operating band of the other antenna, the matching of the transmitting antenna deteriorates as the radiation resistance goes reactive and, according to the invention, because of the inductance L and capacitance C.

[0017] Figs. 7a and b show a fifth example of an antenna structure according to the invention. Of the two antennas there is shown only the one the transmission of which tends to interfere with the reception of the other. A transmitting

PIFA 710 is shown in Fig. 7a from the side of the feed and short-circuit conductors, and in Fig. 7b also laterally but 90 degrees horizontally rotated from the position shown in Fig. 7a. Between the radiating plane 711 and ground plane GND, extending up to both of these, there is in this example a small circuit board 707. The circuit board 707 includes a straight microstrip 712 which serves as a short-circuit conductor, and a microstrip 715 which serves as a feed conductor. The latter is so thin that it has a significant inductance. The feed strip 715 is here connected by its lower end to the antenna port AP of the antenna 710. An intermediate point in the feed strip is capacitively coupled to ground via a chip capacitor 716 on the circuit board 707. This kind of feed arrangement is designed so that the matching of the transmitting antenna is good in its operating band but relatively poor in the operating band of the receiving antenna.

[0018] Figs. 8a and b illustrate a sixth example of an antenna structure according to the invention. In this case, too, the receiving antenna to be shielded is not shown. A transmitting PIFA 810 is shown in Fig. 8a from the side of the feed and short-circuit conductors. Between the radiating plane 811 and ground plane GND, extending up to both of these, there is a small printed circuit board 807. This is in Fig. 8b shown from the back, i.e. from inside the antenna 810. The printed circuit board 807 includes a straight feed microstrip 815 and short-circuit strips 812a and 812b. A first short-circuit strip 812a on the front side of the printed circuit board starts from the radiating plane 811 and forms a rectangular "spiral" to increase the inductance. It continues, after a via, on the back side of the printed circuit board in the other short-circuit strip 812b. The latter is connected to the ground plane by its lower end. On the back side of the printed circuit board there is also a chip capacitor 813 connected in parallel with a coil formed by the short-circuit strips 812a,b. The resulting resonance circuit is designed like in the cases depicted by Figs. 3 and 4: In the operating band of the transmitting antenna 810 the impedance of the resonance circuit is small but in the operating band of the receiving antenna it is high.

[0019] Fig. 9 shows an example of the improved electrical isolation that can be achieved between antennas in accordance with the invention. A test signal is fed into an antenna of the GSM1800 system, and a level measurement is done in the output of the antenna of a GPS receiver in the same radio device. Curve 91 represents the isolation attenuation of the antennas with no special GPS reception shielding. The isolation attenuation is of course at its smallest when the frequency of the test signal is 1575.42 MHz, or the frequency used in the GPS system; the attenuation is then only 3.8 dB. Curve 92 shows the isolation attenuation of the antennas when the transmitting antenna has been modified in accordance with the invention in order to shield GPS reception. A resonance circuit in the transmitting antenna raises the isolation attenuation by about 17 dB at the GPS frequency, making it 20.8 dB. A prior-art isolation arrangement corresponding to Fig. 1 will in practice produce an isolation attenuation of about 10 dB, so the improvement from that arrangement, too, is considerable.

[0020] Fig. 10 shows a radio device MS. It has a first 010 and second 020 antenna. The first antenna includes an arrangement 012 according to the invention.

[0021] Above we described a few solutions according to the invention. The invention does not limit the shapes of antenna elements and additional parts according to the invention, nor the method of manufacturing of the antenna. Also both of the two antennas may include an arrangement according to the invention. This may be the case e.g. when a device includes separate UMTS (Universal Mobile Communication System) and WLAN (Wireless Local Area Network) antennas. The inventional idea may be applied in various ways within the scope defined by the independent claim 1.

Double-antenna and radio apparatus

Claims not available for **CN 1423368 (A)**
Claims of corresponding document: **EP 1315238 (A2)**

1. An arrangement for enhancing electrical isolation between antennas which comprise a first antenna and a second antenna belonging to one and the same radio device, characterized in that at least the first antenna (310; 410; 610; 710; 810) comprises structural parts to degrade its matching at frequencies of an operating band of the second antenna (320; 420).

2. An arrangement according to claim 1 where the first antenna is a PIFA, characterized in that said structural parts to degrade the matching of the first antenna (310; 410; 810) constitute a parallel resonance circuit which replaces a short-circuit conductor in the PIFA and a resonance frequency of which is substantially the same as a resonance frequency of the second antenna (320; 420).

3. An arrangement according to claim 2, characterized in that said parallel resonance circuit comprises at a point corresponding to the short-circuit point of the first antenna a substantially inductive circuit element (314; 414; 812a, 812b) between the radiating plane and ground plane, and a capacitive circuit element (312, 313; 412, 413; 813) which substantially increases capacitance in an area corresponding to the short-circuit point.

4. An arrangement according to claim 1 where the first antenna is a PIFA, characterized in that said structural parts to degrade the matching of the first antenna constitute a series resonance circuit which replaces a feed conductor in the PIFA and the resonance frequency of which is substantially the same as the resonance frequency of the first antenna.

5. An arrangement according to claim 4, characterized in that said series resonance circuit comprises a substantially inductive circuit element (515) and a capacitive circuit element (516) forming a capacitance in series therewith.

6. An arrangement according to claim 1 where the first antenna is a PIFA, characterized in that said structural parts to degrade the matching of the first antenna constitute an inductive circuit element (612) which replaces a short-circuit conductor in the PIFA and a capacitive circuit element (615, 617, 602) which replaces a feed conductor in the PIFA.

7. An arrangement according to claim 1 where the first antenna is a PIFA, characterized in that the arrangement comprises a circuit board (707; 807) between the radiating plane and ground plane of the first antenna (710; 810) and that said structural parts to degrade the matching of the first antenna are located on the circuit board.

8. An arrangement according to any one of the preceding claims, characterized in that said capacitive circuit element is formed of conductive material (312; 412, 413; 615, 617) in connection with the radiating plane and/or ground plane in the first antenna.

9. An arrangement according to any one of the claims 1-7, characterized in that said capacitive circuit element comprises a discrete capacitor (516; 716; 813).

10. An arrangement according to any one of the preceding claims, characterized in that said inductive circuit element is formed of conductive material (314; 414; 515; 612; 715; 812a, 812b) in connection with the radiating plane and/or ground plane in the first antenna.

11. An arrangement according to any one of the preceding claims, characterized in that said inductive circuit element comprises a coil.

12. An arrangement according to claim 11, characterized in that said coil is a spiral-like microstrip (812a) on a surface of a circuit board (807).

13. A radio device (MS) with a first antenna and a second antenna, characterized in that at least the first antenna (010) includes structural parts (012) to degrade its matching at the frequencies of an operating band of the second antenna (020) and thus to enhance the electrical isolation between said antennas.